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(54) **Stator vane for an axial flow turbine**

(57) The invention relates to coolably fixing the root of a stator vane (3) to the stator casing (1) by means of attachment elements, preferably by means of attachment screws (9), which act with a force fit. In order to reduce the thermal stress on the attachment elements and on the stator casing, the invention proposes that the stator vane root be designed as a hollow profile, comprising a radially inner platform (4) matched to the contour of the flow channel (19) and, at a distance from it, a radially outer platform (5) matched to the contour of the stator casing (1), as well as two essentially parallel sidewalls (6,7), wherein the outer platform (5) is equipped with at least one hole to accommodate an attachment element (9), preferably a screw, originating from the stator casing (1). This allows for cooling this cavity without any essential losses of coolant and for installing vanes without any seals between platforms and other vane root parts.
According to one preferred embodiment, the outer platform (5) is detachably connected to the vane root.

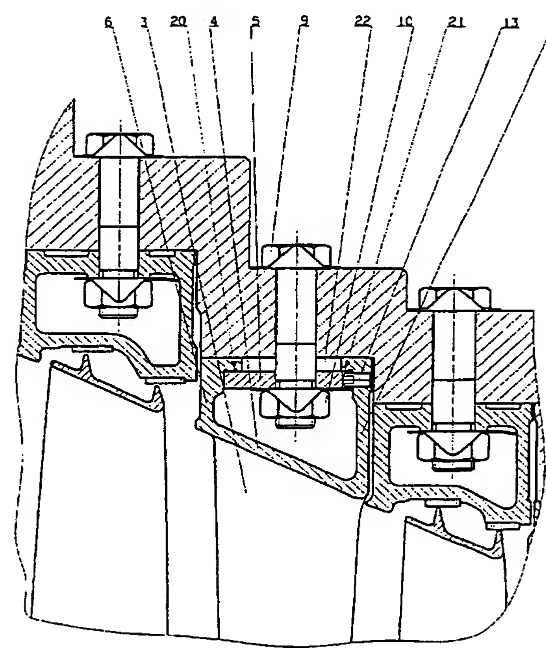


Fig. 3

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## Description

[0001] The invention relates to the design of a stator blade for a turbomachine. In particular, it relates to the design of a vane root to provide a detachable connection between the vane body and the stator casing of such a machine by means of attachment elements, preferably screws, which act with a force fit.

[0002] RU 2038487 CI discloses a widely used type of attachment for the stator vanes to the stator casing of a multistage turbine. The stator, which encloses a conically expanding flow channel, is composed of a plurality of segments. The inner shell of the stator casing has annular recesses,in which projections on the vane root engage and form a positively locking connection between the stator vane and the stator. This solution makes manufacture of the stator casing complex, owing to its complicated structure, characterized by numerous projections and recesses.

[0003] In order to avoid these disadvantages, it is known for the stator and stator vane to be connected by means of attachment screws (A.V. Shtoda et al. " Konstukcija aviazionnych dwigatjeljei", Zhukovsky Military Aircraft Engineering Academy 1958, p. 141). The stator vane root is equipped with an expanded region in the form of a plate, for this purpose. The vane is attached to the casing by means of two screws. In comparison with that mentioned above, this proposal allows the stator casing to be constructed in a considerably simplified manner, with a correspondingly reduced manufacturing cost, since it is possible to dispense with the complicated internal structure. The gap in the labyrinth seal can be designed to be narrower, since there is no need for the play required, for production engineering, between the mutually engaging projections and recesses on the stator and stator vane.

[0004] However, this solution has the disadvantage that two screws are required to fix the vane securely. The root plate is fixed to the stator by one screw upstream of the vane body in the flow direction, and another downstream of it. This additional space requirement for screw arrangement leads, in the end, to the turbine being undesirably lengthened. Temperature differences between the vane root and the stator casing during non-steady-state process phases result in different thermal expansion of the materials. This leads to undesirable material stresses in the area located between the screws. Finally, the complete vane root including the attachment elements is subjected to the influence of the hot process gases, without any protection. This, on the one hand, increases the amount of heat transferred to the stator, while on the other hand uneven areas on the surface cause disturbances in the channel flow.

[0005] The invention is based on the object of providing a stator vane which allows a simple and reliable screw connection to the stator, while in the process avoiding said disadvantages of the prior art solutions.

[0006] The object is achieved according to the invention by designing a stator vane in accordance with the features of claim 1. Advantageous developments of the invention are described in the dependent claims.

[0007] The basic idea of the invention is to design the vane root as a hollow profile, comprising two root platforms which are arranged at a distance from one another, and of which the first, radially inner platform is matched to the conical contour of the flow channel, while the second, radially outer platform is matched to the contour of the corresponding casing wall. Two mutually opposite sidewalls connect the root platforms, enclosing a cavity. The outer root platform is preferably equipped with a hole for accommodating an attachment element, preferably an attachment screw, which fixes the stator vane on the wall of the stator casing.

[0008] The cavity enclosed by said root platforms and sidewalls provides space to accommodate the attachment elements, as will be explained in more detail in the following text.

[0009] The surface of the outer root plate is provided with recesses. When placed against the stator casing, this creates additional cavities, which make it more difficult for heat to be transferred. Alternatively or cumulatively, the inner wall of the stator casing may also have corresponding recesses.

[0010] In one alternative embodiment, the outer root platform is not an integral component of the vane root, but is detachably connected to it. In this case, the vane root- is formed only by the inner expanded region, which faces the vane body and is in the form of a plate, and the two radially oriented walls which are arranged opposite and whose ends are bent inward at right angles. The steps produced in this way act as contact edges for the outer plate.

[0011] In another alternative embodiment, the sidewalls are mutually connected by two partitions so that two walls, the two partitions, the inner root platform, the outer root platform and the cylindrical surface of the stator casing form a cavity. In this case, if the walls and the partitions are tightly fit against the cylindrical casing surface, and this joint is tightened by a screw connection, a sufficiently sealed connection can be created at this joint.

[0012] In this case any possible mass flow values of cooling gas can be supplied into this cavity through a channel made in the casing and through the channel in the outer root platform without worrying about large losses due to its leakage into the flow channel. In this case another channel can be made in both the outer platform and the casing to discharge cooling gas from this cavity.

[0013] In the third alternative embodiment, bearing surfaces of each vane are implemented at different radial levels and are coupled with different cylindrical surfaces of the casing; in this case two bearing surfaces of two adjoining vanes are situated on the same cylindrical surface of the stator.

[0014] This arrangement of vane bearing surfaces makes it possible to reduce heating of one vane root

wall due to its withdrawal from the hot zone interlinked with the flow channel, and to reduce heating of the stator end wall conjugated with the vane wall.

[0015] In the fourth alternative embodiment, sidewalls are arranged along the direction parallel to the longitudinal axis of the stator with their bearing surfaces adjoined to the cylindrical surface and to the end surface of stator casing. Ends of root inner platform adjoin also to the above mentioned surfaces of the stator casing. In this case the fastening element is arranged obliquely with respect to the cylindrical surface and to the end surface of the stator casing, and oriented so that simultaneous pressing of above mentioned bearing surfaces of the stator casing. In this case sufficiently seales cavity isolated from hot gases passing through the gas flow channel is formed between the end surface of stator casing, its cylindrical surface, the vane root inner platform and its two walls.

[0016] This makes it possible to cool internal walls of this cavity by any cooling gas mass flows without misgiving occurrence of large losses due to leakages of coolant into the gas flow channel. In this case an outlet channel for discharge of cooling gas from this cavity can be also implemented in the casing. In so doing cooling of the vane root cavity and even vane airfoil internal cavity (if any) virtually without cooling gas losses, and thus a plant efficiency increase is possible.

[0017] An important advantage of this embodiment is also the possibility for vane mounting without any seals between platforms and other root parts of vanes, because proposed design of joints between the vane root part and the stator casing allows for virtually complete protection of inner stator surface against effect of hot gases from the turbine gas flow path.

[0018] The advantages of the vane root design according to the invention are, in particular, that the heat transferred from the flow channel to the stator is considerably reduced. The gas-filled cavity enclosed by the hollow profile restricts the passage of heat. The root platform, which rests directly against the stator casing, is subject to less thermal stress. This reduces the thermal conduction both via the contact surface and via the attachment element. Overall, this results in the stator casing temperature being lower. The accommodation of the attachment element or elements in the cavity furthermore protects them against the direct influence of the hot process gases which, not least, also increases the reliability of the connection, and thus safety. Since, in this solution, the attachment element does not occupy any additional space in front of and behind the vane body, the axial extent of the root platform is limited to the size governed by the vane body. Thus the invention does not suffer from the disadvantage of lengthening of the turbines with screwed-on stator vanes, over those with stator vanes that are held with a guided joint.

[0019] The root platforms and attachment elements have no effect on the channel flow.

[0020] Finally, it is feasible to apply a cooling medium deliberately to the cavity, and thus provide additional protection against thermal stress in the stator casing and attachment elements.

[0021] The drawings show a plurality of embodiments of the invention, highly schematically. Only those features which are essential to understanding of the invention are shown. Identical or mutually corresponding elements have the same reference symbols.
In the figures:

| | |
|---|---|
| Figure 1 | shows a longitudinal section through a means for fixing a stator vane, according to the invention |
| Figure 2 | shows a cross-sectional illustration along the line A-A shown in Figure 1 |
| Figure 3 | shows a longitudinal section of an alternative embodiment |
| Figure 4 | shows a cross-sectional illustration along the line A-A shown in Fig. 1 of another alternative embodiment |
| Figure 5 | shows a longitudinal section of a third alternative embodiment of a means for fixing a stator vane |
| Figure 6 | shows a longitudinal section of a fourth alternative embodiment |
| Figure 7 | shows a cross-sectional illustration along the line B-B shown in Figure 6. |

[0022] A blade system shown in Figure 1 alternately comprises rows of rotor blades (14) and stator vanes (3) in a conically expanding flow channel (19), surrounded by the stator casing (1). The rotor blades (14), which are anchored in the rotor (not shown) are fitted with covering strip elements (15) at their blade tips. On their upper face, the covering strip elements (15) have sealing ribs (16) which run parallel to the direction Of rotation and run against sealing strips(17)on a heat shield (12) that is connected to the stator casing (1)
The conically expanding stator casing (1) is constructed in the form of steps, comprising a plurality of cylindrical sections (2) of increasing diameter. These cylindrical sections (2) communicate in their radial and axial extent with the rows of blades (3) and (14). Each of these sections (2) is alternately fitted with a stator vane (3) or heat shield (12), so as to produce an approximately continuous, conical channel internal contour. The root of the stator vane (3) forms a hollow profile, comprising a radially inner root plate (4) and a radially outer root platform (5), connected by parallel sidewalls (6) and (7) running transversely with respect to the flow direction. The radially inner platform (4) has an inclination which communicates with the conicity of the flow channel (19). The downstream wall (6) is thus generally shorter than the wall (7), so that the cavity (18) that is formed for each stator row has a more or less pronounced trapezoidal to approximately triangular cross-sectional shape. The root platforms (4) of adjacent vanes (3) abut against one another and form a continuous, approximately closed

channel wall in each row of vanes (3) , as can be seen from Figure 2. The radially outer root platform (5) rests on the cylindrical region (2) of the stator casing (1). Recesses (11) on the platform surface (5) and/or casing surface (1) reduce the amount of heat transmitted. The stator casing (1) and platform (5) have coaxial throughholes for an attachment screw (9). The screw shank which passes through the stator casing (1) from the outside projects into the cavity (18) enclosed by the hollow profile, where it interacts with a threaded nut (10) . The term threaded nut (10) should not be regarded in a narrow sense here. For example, it may also in this case be an insert integrated in the root platform and having a threaded hole. When the screw (9), (10) is tightened, the stator vane (3) is connected to the stator casing (1) with a force fit and a positive lock. In addition to being fixed by the attachment screw (9), the vane (3) is also held by the positive lock with the wall of the stator casing (1) in the region of the contact surface (8) . The protected arrangement within the cavity (18) means that the screw shank (9) and the threaded nut (10) are largely removed from the influence of the process gases. At the same time, they cannot exert any negative influence on the flow conditions in the flow channel (19) . The channel inner wall has a largely smooth contour. Coolant can be fed into the cavity (18) by means of channels (23) made in the stator casing (1) and of channels (24) made in the root outer platform (5).

**[0023]** The embodiment shown in Figure 3 differs from that shown in Figure 1 in that the platform (5) is no longer an integral component of the stator vane root, but is produced separately from it, as a separate element, and it inserted in the profile only during assembly. This embodiment has advantages particularly in production, in conjunction with the use of vanes with internal cooling. This measure simplifies the process of casting and fitting these vanes.

**[0024]** In this case, the outer ends of the walls (6) and (7) are bent inward at right angles in order to form two contact surfaces (20) and (21), lying in the same plane, for the plate (5) which is to be inserted. A gap (22) which reduces the heat transfer is in this case formed between the stator casing (1) and the root platform (5), depending on the wall thickness above the contact surfaces (20) and (21). The outer platform (5) is then inserted into the hollow profile of the vane root during the assembly process, or, in a kinematically reversed manner, the hollow profile is pushed over the plate (5), which is connected loosely to the attachment screw (9). The root plate (5) can be fixed in the hollow profile by using a locking pin (13).

**[0025]** An embodiment of the vane (3) root is shown in Figure 4 where crosspieces (25) and (26) connect vane walls (6) and (7) (Fig. 1) one to another and adjoin to the inner root platform (4). Thus, the cavity (31 is formed between two walls (6), (7), two crosspieces (25), (26), inner root platform (4) and surface of the cylindrical casing section (2). Due to formation of tight fitting the walls (6), (7) and crosspieces (25), (26) to the surface of the cylindrical casing section (2), and due to tightening of this joint by threaded connection implemented in the platform (5) and consisting of the screw (9) and the threaded hole (27) a sufficiently sealed connection can be created in this joint. This allows the walls of cavity (31) to be cooled virtually without any loss of coolant. To feed coolant into the cavity (32), inlet channels (23)are made in the casing (1), and inlet channels (24) are made in the platform (5). Appropriate channels (29), (30) are provided for discharge of coolant.

**[0026]** Still another embodiment of the vane (3) root is shown in Figure 5 where bearing surfaces (32), (33) are made at different radial levels. Each of these surfaces made in the same vane is conjugated with various cylindrical surfaces of casing sections. In addition, both bearing surfaces (33) of the vane (3) and bearing surfaces (32) of the vane (34) are situated on the same cylindrical surface of the stator section. This allows the vane (35) root wall and the situated oppositely wall of stator (1) to be brought out of the hot zone effected by the flow channel (19), and thereby heating these walls to be reduced.

**[0027]** One further embodiment of the vane (3) root is shown in Figure 6 where walls (6) and (7) (Fig. 7)are arranged in parallel to the longitudinal axis of stator (1). Bearing surfaces (37) and (38) of walls (6) and (7) adjoin simultaneously to the cylindrical surface (39) and to the end surface (40) of the stator casing (1). The inner root platform (4) adjoins also to above mentioned surfaces of stator casing section at contact surfaces (36) and (28). Thus, side walls (6) and (7), the inner root wall (4), the cylindrical surface (39) and the end surface (40) form a sufficiently sealed cavity (31) that is virtually completely separated out of hot gases passing through the flow channel (19). A fastening element (9) can be arranged close by the line of intersection between the cylindrical surface (39) and the end surface (40) of stator casing (1) and is inclined at the angle $\alpha$ to the end surface (40) that allows for providing simultaneous pressure of the above mentioned bearing surfaces (37), (38) and contact surfaces (36) and (28) to surfaces (39), (40) of casing section. The threaded hole (27) for a fastening element is situated directly in the outer root platform (5). This embodiment allows also making an inlet channel (23) and the outlet channel (27) in the stator casing (1) to feed and to discharge coolant for cooling internal surfacesof stator walls and of vane root parts. In this case there exist virtually no coolant leakage from the cavity (31) into the flow channel (19).

**[0028]** It is self-evident that the invention is not limited to the described embodiments. In particular, a person skilled in the art will see from the description of the invention the possibility of transferring the design of a stator vane root according to the invention, creating a hollow profile, to accommodate the attachment elements, to other components with comparable operating conditions as well, in particular in the turbomachine field. For

example, without departing from the scope of the invention, a heat protective shield screwed to the stator wall can thus be designed in an analogous manner as a hollow profile with an inner platform matched to the channel contour and an outer platform fixed to the casing by means of an attachment element.

List of reference symbols

[0029]

| | |
|---|---|
| 1 | Stator casing |
| 2 | Cylindrical casing sections |
| 3 | Stator vane |
| 4 | Radially inner root platform |
| 5 | Radially outer root platform |
| 6 | Wall on the vane root |
| 7 | Wall on the vane root |
| 8 | Contact surface |
| 9 | Screw |
| 10 | Threaded nut |
| 11 | Recesses |
| 12 | Heat shield |
| 13 | Pin |
| 14 | Rotor blade |
| 15 | Covering strip element |
| 16 | Sealing ribs |
| 17 | Sealing strips |
| 18 | Cavity |
| 19 | Flow channel |
| 20 | Contact surface |
| 21 | Contact surface |
| 22 | Gap |
| 23 | Inlet channel in the stator casing |
| 24 | Inlet channel in the outer root platform |
| 25 | Crosspiece |
| 26 | Crosspiece |
| 27 | Threaded hole |
| 28 | Contact surface |
| 29 | Coolant discharge channel in the outer root platform |
| 30 | Coolant discharge channel in the stator casing |
| 31 | Vane root cavity |
| 32 | Bearing surface |
| 33 | Bearing surface |
| 34 | Stator vane |
| 35 | Vane root wall |
| 36 | Contact surface |
| 37 | Bearing surface |
| 38 | Bearing surface |
| 39 | Cylindrical surface of the casing section |
| 40 | End surface of the casing section |

## Claims

1. A stator vane (3) for an axial flow turbine having a flow channel (19) which expands conically and has a root platform which is connected with a force fit and a positive lock to the stator casing (1),
**characterized in that**
the stator vane root is in the form of a hollow profile, comprising a radially inner root platform (4) which is matched to the contour of the flow channel (19), and, at a distance from it, a radially outer root platform (5), matched to the contour of the stator casing (1) as well as one or two essentially parallel sidewalls (6) and (7),
wherein the outer platform (5) is equipped with at least one hole for accommodating an attachment element (9) by which the vane is fastened to the stator casing (1).

2. The stator vane (3) as claimed in claim 1,
**characterized in that**
the contact surface between the root platform (5) and the stator casing (1) has recesses (11).

3. The stator vane (3) as claimed in claim 2,
**characterized in that**
the surface of the root platform (5) is provided with recesses (11).

4. The stator vane (3) as claimed in claim 3,
**characterized in that**
the bearing surfaces (32) and (33) of the same stator vane (3) are made at different radial levels and matched with different surfaces of cylindrical casing sections (2), bearing surface (32) of one stator vane and bearing surface (33) of another stator vane being arranged in one cylindrical casing section (2).

5. The stator vane (3) as claimed in claim 1,
**characterized in that**
the outer platform (5) is detachably connected to the vane root.

6. The stator vane (3) as claimed in claim 5,
**characterized in that**
the radially outer ends of the sidewalls (6) and (7) of the vane root are bent at least approximately at right angles inward, and form two contact surfaces (20) and (21), lying in parallel planes, for the contact with outer root platform (5) .

7. The stator vane (3) as claimed in claim 1,
**characterized in that**
means are provided for applying a cooling medium to the cavity (18) in the installed state.

8. The stator vane as claimed in claim 1,
**characterized in that**
two crosspieces (25) and (26) are provided between sidewalls (6) and(7).

9. The stator vane as claimed in claim 8,

**characterized in that**
end surfaces of sidewalls (6) and (7) and of cross-pieces (25) and (26) turned to the surface of cylindrical casing section (2) tightly adjoins to said surface of cylindrical casing section (2), and together wifh inner root platform (4) they form the cavity (31) essentially tightly separated from the flow channel (19).

**10.** The stator vane as claimed in claim 1,
**characterized in that**
sidewalls (6) and (7) with bearing surfaces (37) and (38) are arranged in parallel to the longitudinal axis of stator (1), and the bearing surfaces (37) and (38) adjoin at the same time to the cylindrical surface (39) and to the end surface (40) of the stator casing (1); together wifh inner root platform (4) having contact surfaces (36) and (28) and adjoining also to said surfaces of stator casing (1) they form the cavity (31) essentially tightly separated from the flow channel (19), and attachment element (9) is inclined to the end surface (40) of the stator casing (1) at such angle that can ensure simultaneous pressing against above mentioned surfaces.

**11.** The stator vane as claimed in claim 1,
**characterized in that**
means (23) is provided to feed coolant into the cavity (18) or (31) in installed state.

**12.** The stator vane as claimed in claim 11,
**characterized in that**
means (30) is provided to discharge coolant from the cavity (31) in installed state.

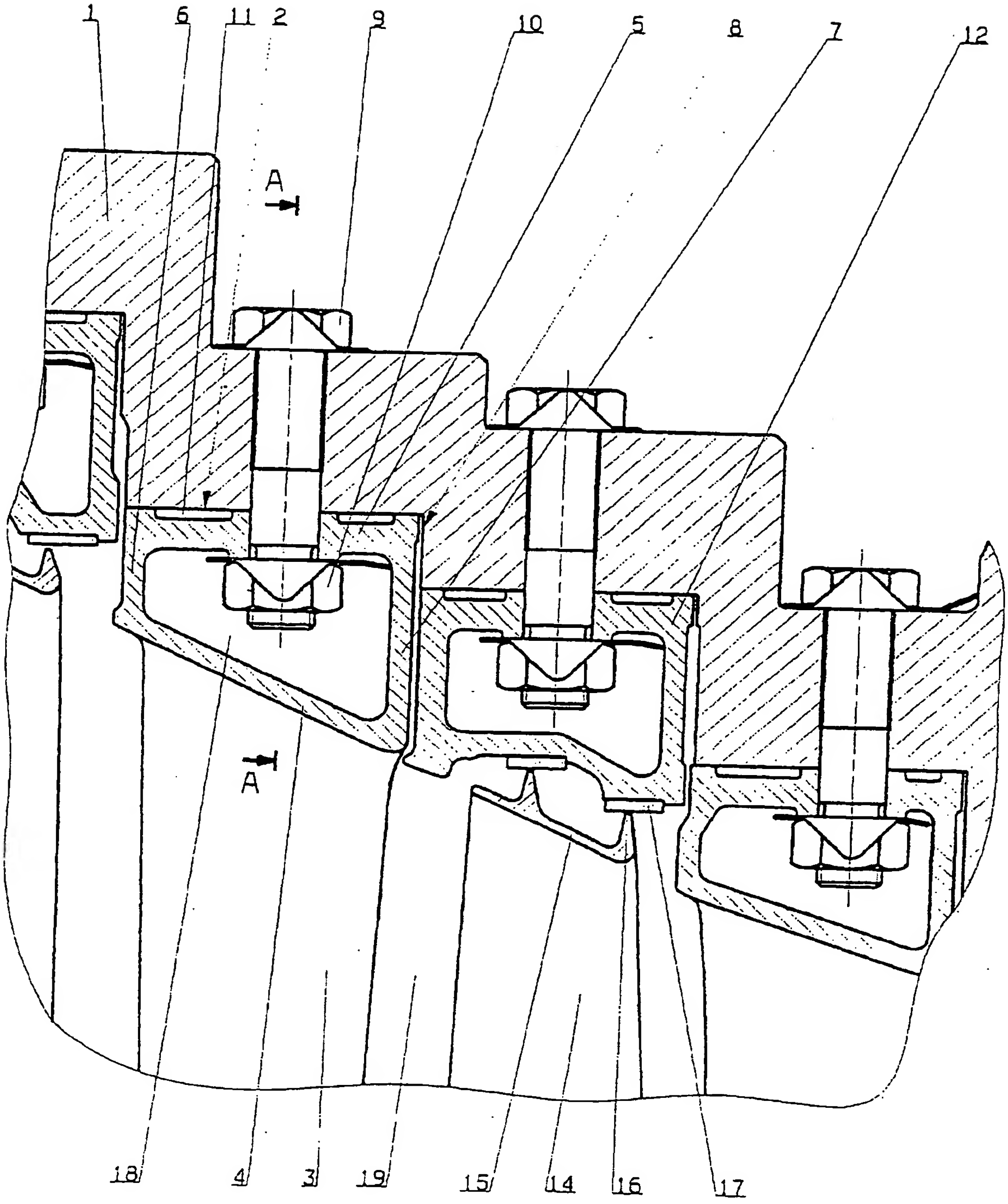


Fig. 1

A-A

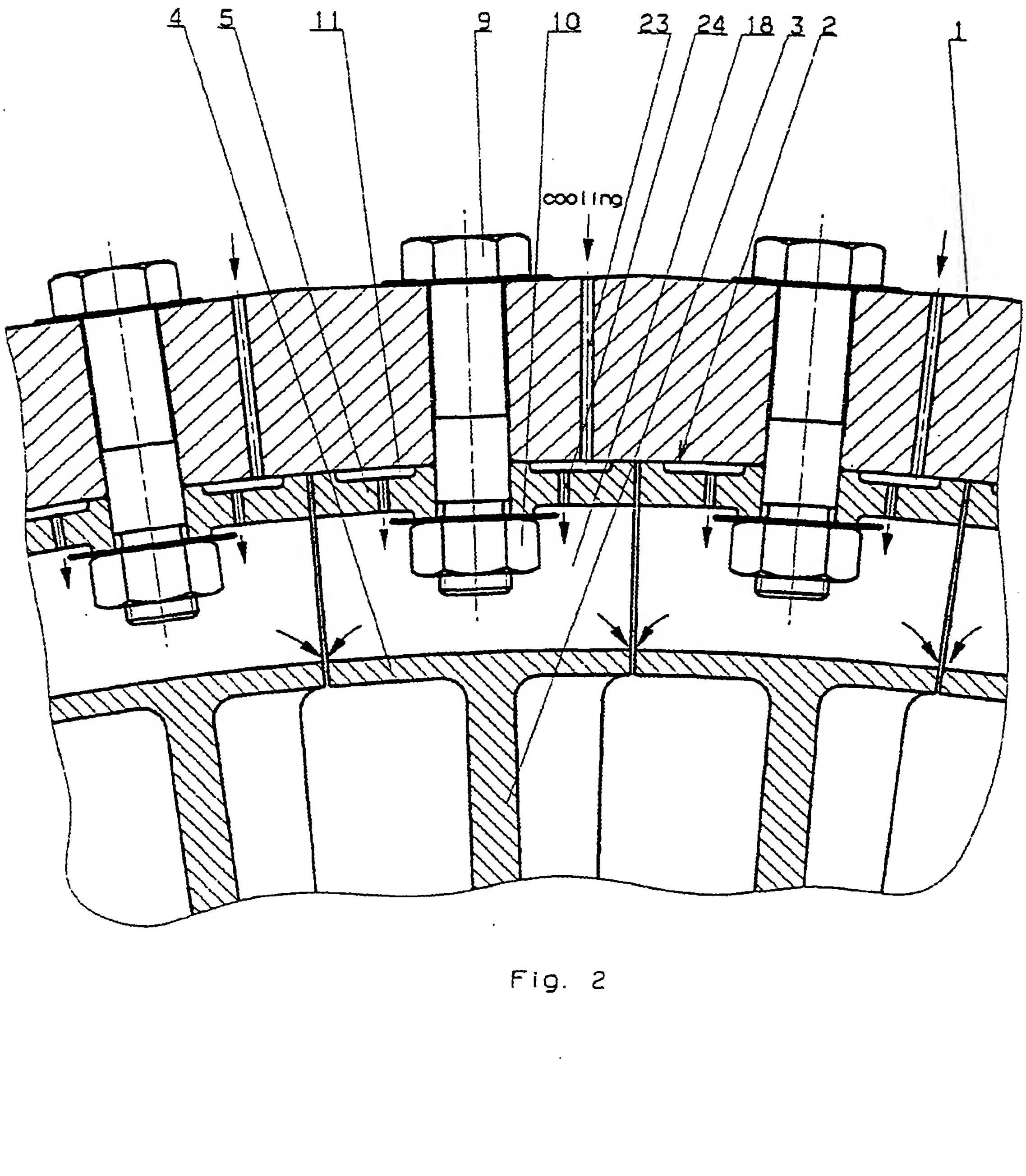


Fig. 2

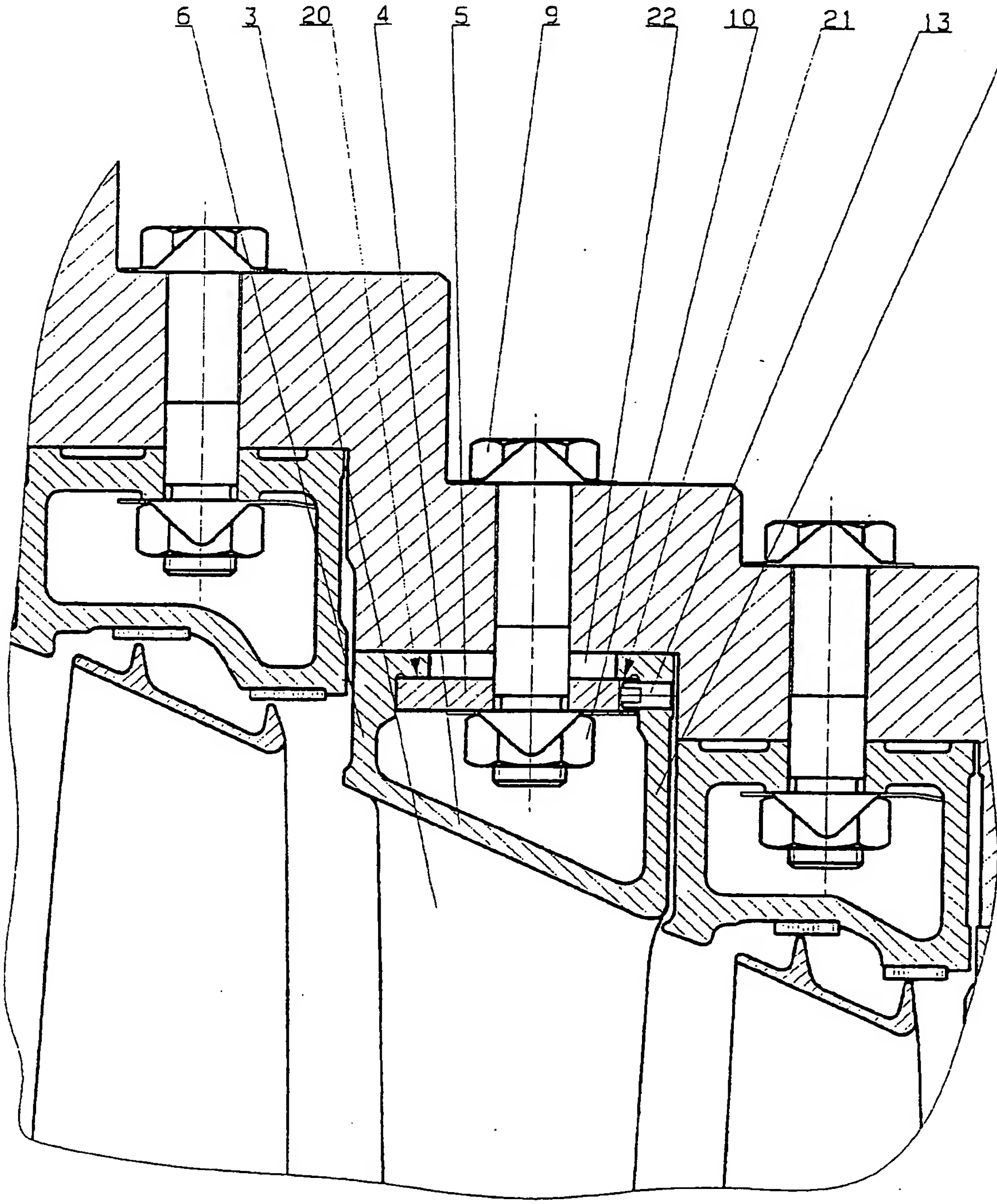


Fig. 3

A-A

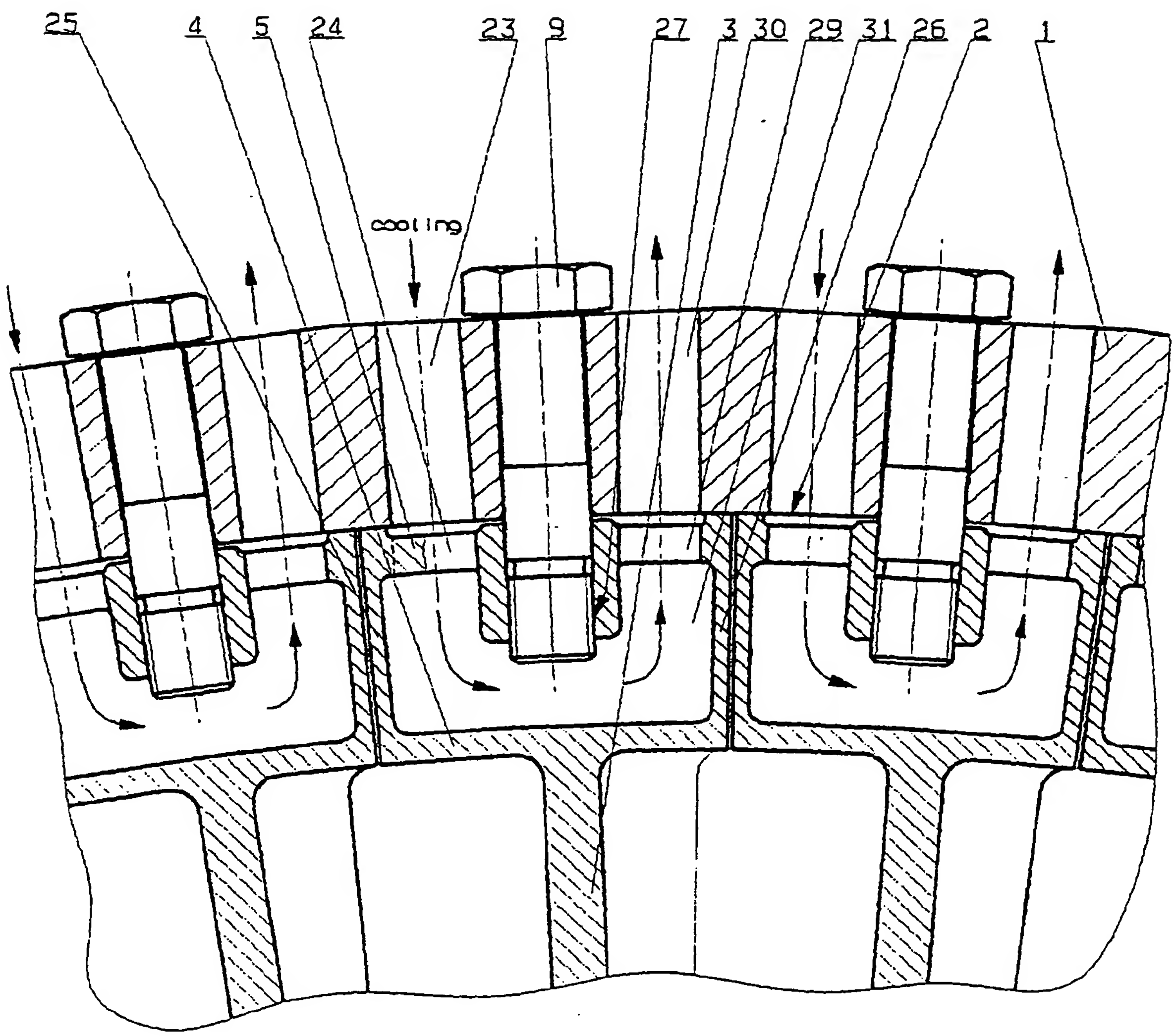


Fig. 4

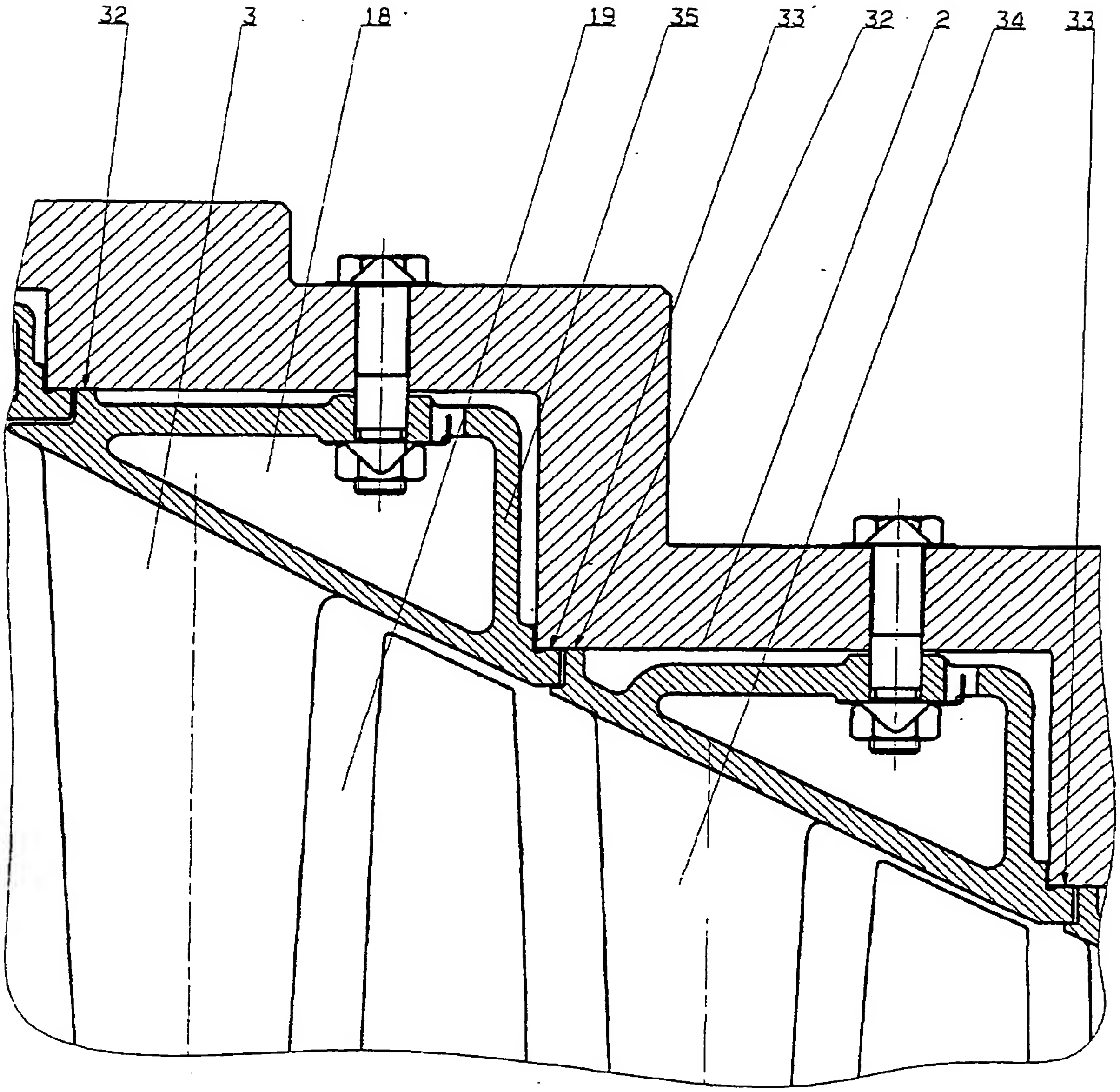


Fig 5

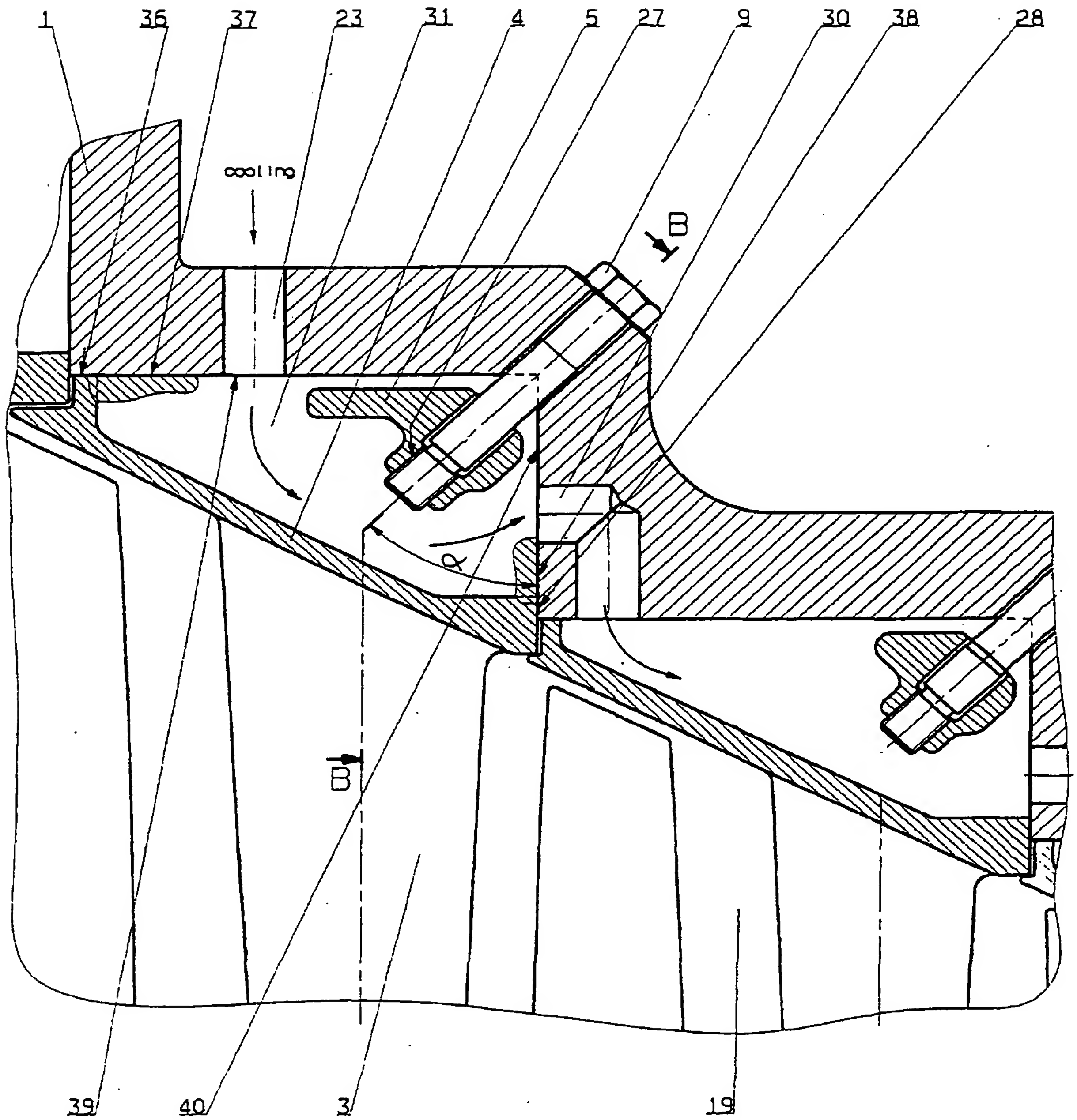


Fig 6

B-B

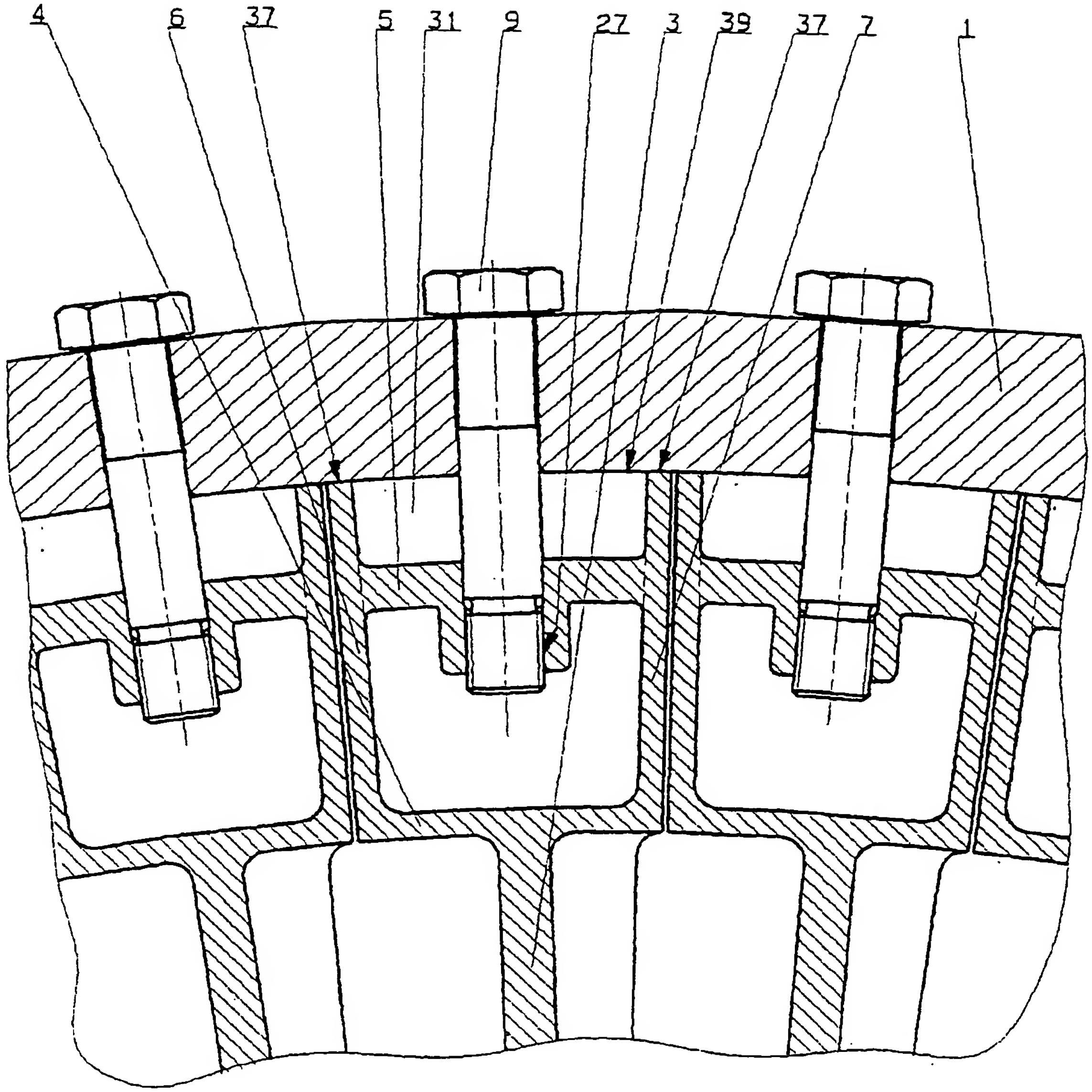


Fig. 7